UNC-5067

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Title: NEUTRON CROSS SECTIONS
OF NATURAL CHLORINE

Prepared by

M. H. Kalos
J. H. Ray

Date: 30 September 1963

Contract No.: DA-18-108-CML-7156
(UNC Project 2185)

UNITED NUCLEAR DEVELOPMENT DIVISION

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United Nuclear Corporation, Development Division, White Plains, N. Y.

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UNC-5067
TOPICAL REPORT

Title: NEUTRON CROSS SECTIONS OF NATURAL CHLORINE

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Date: 30 September 1963

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Previous Reports Published on this Contract

UNC-5038	M. H. Kalos et al., Revised Cross Sections for Neutron Interactions with Oxygen and Deuterium (Aug. 31, 1962).

ABSTRACT

Complete sets of cross sections for natural chlorine are presented for the range of incident neutron energies from 0.02 ev to 18 Mev.

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TABLES

1. INTRODUCTION

The naturally occurring isotopic mixture of chlorine consists of 75.4% Cl^{35} and 24.6% Cl^{37}. The following cross sections for this mixture have been compiled for incident neutron energies from 0.02 ev to 18 Mev: σ_T, $\sigma_{n,\gamma}$, $\sigma_{n,p}$, $\sigma_{n,\alpha}$, $\sigma_{n,d}$, $\sigma_{n,2n}$, $\sigma_{n,n'}$, $\sigma_{n,x}$, and $\sigma_{n,n}$. The data are presented in Table 1. Cross sections for production of neutrons by inelastic scattering, for production of gamma rays by inelastic scattering, and for production of gamma rays by neutron capture are given. Legendre polynomial coefficients to describe the angular distribution of elastically scattered neutrons are also given.

It should be stated here that very little information is available on neutron interactions with chlorine in the energy range above about 0.25 Mev.

1.1 NEUTRON CROSS SECTIONS FOR CHLORINE

1.1.1 The Total Cross Section, σ_T

In the energy ranges below 1100 ev and above 0.2 Mev, the total cross section was taken from BNL 325.[1,2] From 0.2 to 0.75 Mev the data were averaged in such a way as to preserve as well as possible the shape of the data. In this averaging process the data were integrated by trapezoidal rule from the midpoint of the interval below the mesh point in question to the midpoint of the interval above it, and the integral divided by the energy range of the integration.

Table 1 — Chlorine – Cross Sections as a Function of Energy

E, Mev	σ_T barns	$\sigma_{n,\gamma}$ mb	$\sigma_{n,p}$ mb	$\sigma_{n,\alpha}$ mb	$\sigma_{n,d}$ barns	$\sigma_{n,2n}$ mb	$\sigma_{n,n'}$ barns	$\sigma_{n,x}$ barns	σ_n barns
18.0	2.00	.0	33.0	90.0	.151	22.	.704	1.000	1.000
17.1	2.01		30.0	91.0	.154	18.5	.707	1.000	1.010
16.3	2.01		29.0	95.0	.151	15.5	.710	1.000	1.010
15.5	2.01		29.0	97.0	.146	12.0	.716	1.000	1.010
14.75	2.00		31.3	104.0	.136	8.4	.720	1.000	1.000
14.0	1.98		34.5	107.0	.130	5.0	.724	1.000	.980
13.3	1.96		39.0	114.0	.109	3.0	.735	1.000	.960
12.7	1.97		45.7	122.5	.088	1.4	.742	1.000	.970
12.1	1.94		53.0	130.0	.062	.0	.755	1.000	.940
11.5	1.95		58.0	139.2	.030		.773	1.000	.950
10.9	2.00		66.0	146.0	.000		.788	1.000	1.000
10.4	2.05		73.0	153.0			.804	1.030	1.020
9.89	2.10		81.0	160.0			.829	1.070	1.030
9.41	2.20		89.0	165.0			.856	1.110	1.090
8.95	2.26		97.0	169.0			.894	1.160	1.100
8.51	2.32		101.0	171.0			.923	1.195	1.125
8.10	2.38		104.0	172.0			.944	1.220	1.160
7.70	2.42		105.0	171.0			.974	1.250	1.170
7.33	2.49		105.0	170.0			.995	1.270	1.220
6.97	2.55		105.0	167.0			1.008	1.280	1.270
6.63	2.60		105.0	163.0			1.002	1.270	1.330
6.30	2.64		105.0	157.0			.998	1.260	1.380
6.00	2.68		105.0	150.0			.975	1.230	1.450
5.70	2.70		105.0	142.0			.948	1.195	1.505
5.43	2.72		105.0	131.0			.924	1.160	1.560
5.16	2.74		105.0	112.0			.893	1.110	1.630
4.91	2.75		105.0	100.0			.858	1.063	1.687
4.67	2.80		105.0	89.0			.836	1.030	1.770
4.44	2.85		104.0	76.0			.820	1.000	1.850
4.23	2.90		103.0	64.0			.803	.970	1.930
4.02	2.95		101.0	47.0			.784	.932	2.018
3.82	3.01		99.0	37.0			.767	.903	2.107
3.64	3.07		96.2	28.0			.749	.873	2.197
3.46	3.09		93.5	21.0			.728	.843	2.247
3.29	3.10		91.0	16.0			.699	.806	2.294

Table 1 — (Continued)

E, Mev	σ_T barns	$\sigma_{n,\gamma}$ mb	$\sigma_{n,p}$ mb	$\sigma_{n,\alpha}$ mb	$\sigma_{n,d}$ barns	$\sigma_{n,2n}$ mb	$\sigma_{n,n'}$ barns	$\sigma_{n,x}$ barns	σ_n barns
3.13	3.10	.0	88.0	13.0	.000	.0	.674	.775	2.325
2.97	3.10		85.0	8.6			.649	.743	2.357
2.83	3.10		81.5	6.2			.625	.713	2.387
2.69	3.10		78.5	4.2			.597	.680	2.420
2.56	3.09		76.0	2.8			.578	.657	2.433
2.44	3.05		72.0	1.9			.561	.635	2.415
2.32	3.01		68.5	1.1			.540	.610	2.400
2.21	2.98		65.2	.66			.518	.584	2.397
2.10	2.96		61.8	.33			.492	.554	2.406
2.00	2.93		58.3	.1			.464	.522	2.408
1.90	2.90		55.0	.0			.430	.485	2.415
1.81	2.86	.016	52.0				.393	.445	2.415
1.72	2.81	.017	48.5				.354	.403	2.407
1.63	2.76	.018	45.0				.335	.380	2.380
1.55	2.72	.019	41.5				.314	.356	2.364
1.48	2.68	.020	38.5				.294	.333	2.347
1.41	2.63	.021	36.0				.270	.306	2.324
1.34	2.58	.022	33.0				.243	.276	2.304
1.27	2.52	.023	30.0				.210	.240	2.280
1.21	2.46	.024	27.1				.176	.203	2.257
1.15	2.41	.026	24.7				.139	.164	2.246
1.096	2.36	.027	22.2				.097	.119	2.241
1.042	2.31	.029	20.1				.047	.067	2.243
.991	2.23	.030	18.0				.000	.018	2.212
.943	2.22	.031	16.2					.016	2.204
.897	2.31	.033	14.5					.015	2.295
.853	2.35	.035	12.8					.013	2.337
.812	2.30	.036	11.2					.011	2.289
.772	2.150	.038	9.5					.010	2.140
.734	2.203	.040	8.0					.008	2.195
.699	2.232	.043	6.8					.007	2.225
.666	2.073	.045	5.6					.006	2.067
.632	2.396	.047	4.3					.004	2.392
.601	2.079	.049	3.25					.003	2.076

Table 1 — (Continued)

E, Mev	σ_T barns	$\sigma_{n,\gamma}$ mb	$\sigma_{n,p}$ mb	$\sigma_{n,\alpha}$ mb	$\sigma_{n,d}$ barns	$\sigma_{n,2n}$ mb	$\sigma_{n,n'}$ barns	$\sigma_{n,x}$ barns	σ_n barns
.572	2.116	.052	2.40	.0	.000	.0	.000	.002	2.114
.544	2.357	.054	1.75					.002	2.355
.518	2.246	.057	1.25					.001	2.245
.492	2.242	.060	.66					.001	2.241
.468	2.420	.064	.25					.000	2.420
.445	1.880	.067	.02					.000	1.880
.424	2.395	.070	.015					.000	2.395
.403	2.660	.074	.013					.000	2.660
.383	2.136	.077	.012					.000	2.136
.365	1.869	.081	.011					.000	1.869
.347	3.167	.086	.011					.000	3.167
.330	1.567	.090	.010					.000	1.567
.314	2.082	.094	.010					.000	2.082
.299	1.693	.100	.010					.000	1.693
.284	2.246	.105	.010					.000	2.246
.270	1.712	.110	.010					.000	1.712
.257	1.884	.115	.010					.000	1.884
.244	1.792	.122	.011					.000	1.792
.233	1.980	.128	.011					.000	1.980
.221	2.055	.134	.012					.000	2.055
.210	1.493	.140	.012					.000	1.493
.200	3.054*	.332*	.013					.000	3.054
.190	2.159*	.513*	.014					.001	2.158
.181	1.334*	.170*	.014					.000	1.334
.172	1.000	.025	.015					.000	1.000
.163	1.700	.025	.016					.000	1.700
.155	1.488*	.163*	.017					.000	1.488
.148	2.165*	.215*	.018					.000	2.165
.141	2.279*	1.042*	.019					.001	2.278
.134	2.025*	.941*	.020					.001	2.024
.127	1.367*	.812*	.021					.001	1.366
.121	1.100	.040	.022					.000	1.100

*Averaged over fine structure of resonance.

Table 1 — (Continued)

E, Mev	σ_T barns	$\sigma_{n,\gamma}$ mb	$\sigma_{n,p}$ mb	$\sigma_{n,\alpha}$ mb	$\sigma_{n,d}$ barns	$\sigma_{n,2n}$ mb	$\sigma_{n,n'}$ barns	$\sigma_{n,x}$ barns	σ_n barns
.115	2.321*	.919*	.023	.0	.000	.0	.000	.001	2.320
.1096	.800	.050	.024					.000	.800
.1042	1.906*	1.243*	.025					.001	1.905
.0991	.800	.014	.026					.000	.800
.0943	1.000	.008	.027					.000	1.000
.0897	1.111	.007	.028					.000	1.111
.0853	1.159	.006	.030					.000	1.159
.0812	1.190	.007	.032					.000	1.190
.0772	1.240	.010	.034					.000	1.240
.0734	1.410	.040	.036					.000	1.410
.0699	2.573*	4.625*	.037					.005	2.568
.0666	.996*	.802*	.039					.001	.995
.0632	2.203*	7.095*	.041					.007	2.196
.0601	2.892*	7.463*	.043					.008	2.884
.0572	1.100	.126	.046					.000	1.100
.0544	1.556*	5.262*	.048					.005	1.551
.0518	1.300	.120	.050					.000	1.300
.0492	2.000	.320	.053					.000	2.000
.0468	6.634*	8.071*	.056					.008	6.626
.0445	.760	.090	.058					.000	.760
.0424	.920	.060	.061					.000	.920
.0403	1.030	.047	.064					.000	1.030
.0383	1.110	.038	.067					.000	1.110
.0365	1.190	.036	.071					.000	1.190
.0347	1.260	.043	.075					.000	1.260
.0330	1.370	.057	.079					.000	1.370
.0314	1.480	.080	.083					.000	1.480
.0299	1.670	.170	.087					.000	1.670
.0284	2.100	.550	.092					.001	2.099
.0270	9.483*	20.646*	.096					.021	9.462
.0257	14.001*	26.056*	.101					.026	13.975
.0244	.300	1.744	.106					.002	.298

*Averaged over fine structure of resonance.

Table 1 — (Continued)

E, Mev	σ_T barns	$\sigma_{n,\gamma}$ mb	$\sigma_{n,p}$ mb	$\sigma_{n,\alpha}$ mb	$\sigma_{n,d}$ barns	$\sigma_{n,2n}$ mb	$\sigma_{n,n'}$ barns	$\sigma_{n,x}$ barns	σ_n barns
.0233	.560	.450	.111	.0	.000	.0	.000	.001	.559
.0221	.670	.200	.117					.000	.670
.0210	.740	.140	.124					.000	.740
.0200	.830	.128	.131					.000	.830
.0190	.980	.150	.138					.000	.980
E, kev									
18.1	1.300	.330	.146					.000	1.300
17.2	57.759**	798.700**	159.730**					.958	56.801
16.3	.640	1.5	.300					.002	.638
15.5	1.70	1.5	.300					.002	1.698
14.8	65.037**	1048.2**	201.64**					1.250	63.787
14.1	.760	.9	.200					.001	.759
13.4	.861	.16	.030					.000	.861
12.7	.920	.11	.013					.000	.920
12.1	.950	.09	.008					.000	.950
11.5	.990	.09	.006					.000	.990
10.96	1.02	.10	.005					.000	1.020
10.42	1.06	.13	.005					.000	1.060
9.91	1.11	.20	.004					.000	1.110
9.43	1.20	.45	.004					.000	1.200
8.97	1.50	2.5	.004					.003	1.497
8.53	9.762*	92.421*	.004					.092	9.670
8.12	.930	.90	.003					.001	.929
7.72	.975	.30	.003					.000	.975
7.34	1.01	.20	.003					.000	1.010
6.99	1.03	.17	.003					.000	1.030
6.66	1.05	.153	.003					.000	1.050
6.32	1.08	.146	.003					.000	1.080
6.01	1.09	.144	.003					.000	1.090

*Averaged over fine structure of resonance.

**Value at peak of resonance near tabulated energy.

Table 1 — (Continued)

E, kev	σ_T barns	$\sigma_{n,\gamma}$ mb	$\sigma_{n,p}$ mb	$\sigma_{n,\alpha}$ mb	$\sigma_{n,d}$ barns	$\sigma_{n,2n}$ mb	$\sigma_{n,n'}$ barns	$\sigma_{n,x}$ barns	σ_n barns
5.72	1.10	.148	.003	.0	.000	.0	.000	.000	1.100
5.44	1.11	.159	.003					.000	1.110
5.18	1.12	.171	.004					.000	1.120
4.92	1.16	.200	.005					.000	1.160
4.68	1.21	.280	.010					.000	1.210
4.45	1.50	1.0	.050					.001	1.499
4.24	23.684*	11828.*	828.*					12.656	11.028
4.03	1.20	1.0	.040					.001	1.199
3.83	1.24	.318	.007					.000	1.240
3.65	1.26	.310	.005					.000	1.260
3.47	1.28	.325	.005					.000	1.280
3.30	1.30	.350	.004					.000	1.300
3.14	1.32	.385	.004					.000	1.320
2.99	1.34	.430	.005					.000	1.340
2.84	1.37	.475	.005					.000	1.370
2.70	1.40	.525	.005					.001	1.399
2.57	1.43	.580	.005					.001	1.429
2.44	1.46	.655	.006					.001	1.459
2.33	1.49	.710	.006					.001	1.489
2.21	1.51	.800	.007					.001	1.509
2.10	1.56	.890	.007					.001	1.559
2.00	1.60	1.00	.008					.001	1.599
1.90	1.63	1.10	.009					.001	1.629
1.81	1.66	1.22	.010					.001	1.659
1.72	1.69	1.39	.011					.001	1.689
1.63	1.73	1.57	.012					.002	1.728
1.55	1.77	1.75	.014					.002	1.768
1.48	1.81	2.00	.015					.002	1.808
1.41	1.85	2.17	.017					.002	1.848
1.34	1.89	2.40	.019					.002	1.888
1.27	1.93	2.80	.021					.003	1.927
1.21	1.97	3.10	.027					.003	1.967

*Averaged over fine structure of resonance.

Table 1 — (Continued)

E, kev	σ_T barns	$\sigma_{n,\gamma}$ mb	$\sigma_{n,p}$ mb	$\sigma_{n,\alpha}$ mb	$\sigma_{n,d}$ barns	$\sigma_{n,2n}$ mb	$\sigma_{n,n'}$ barns	$\sigma_{n,x}$ barns	σ_n barns
1.15	2.01	3.60	.060	.0	.000	.0	.000	.004	2.006
1.096	13.419**	10122.**	1012.0**					11.134	2.285
1.042	2.10	5.0	.045					.005	2.095
.991	2.15	4.8	.035					.005	2.145
.943	2.20	5.25	.036					.005	2.195
.897	2.25	5.90	.038					.006	2.244
.853	2.30	6.55	.041					.007	2.293
.812	2.36	7.33	.046					.007	2.353
.772	2.42	8.10	.051					.008	2.412
.734	2.48	9.00	.058					.009	2.471
.699	2.54	9.90	.068					.010	2.530
.666	2.60	10.80	.078					.011	2.589
.633	2.67	12.00	.092					.012	2.658
.601	2.74	13.50	.110					.014	2.726
.572	2.82	15.00	.14					.015	2.805
.544	2.89	16.50	.17					.017	2.873
.518	2.97	18.70	.24					.019	2.951
.492	3.05	21.00	.35					.021	3.029
.468	3.13	25.00	.60					.026	3.104
.445	3.21	32.00	1.30					.033	3.177
.424	3.30	150.	3.00					.153	3.147
.403	193.76**	155750.**	21801.**					177.551	16.209
.383	3.52	180.	6.00					.186	3.334
.365	3.52	43.	1.70					.045	3.475
.347	3.60	40.2	.80					.041	3.559
.330	3.69	42.3	.60					.043	3.647
.314	3.80	45.	.50					.046	3.754
.299	3.91	49.	.45					.049	3.861
.284	4.07	52.5	.42					.053	4.017
.270	4.21	57.	.41					.057	4.153
.257	4.36	61.	.41					.061	4.299
.244	4.52	66.5	.42					.067	4.453

**Value at peak of resonance near tabulated energy.

Table 1 — (Continued)

E, kev	σ_T barns	$\sigma_{n,\gamma}$ mb	$\sigma_{n,p}$ mb	$\sigma_{n,\alpha}$ mb	$\sigma_{n,d}$ barns	$\sigma_{n,2n}$ mb	$\sigma_{n,n'}$ barns	$\sigma_{n,x}$ barns	σ_n barns
.233	4.68	72.	.43	.0	.000	.0	.000	.072	4.608
.221	4.84	77.5	.45					.078	4.762
.210	4.95	83.5	.475					.084	4.866
.200	5.08	90.	.50					.091	4.989
.190	5.25	97.	.53					.098	5.152
E, ev		$\sigma_{n,\gamma}$ barns							
181.	5.40	.103	.56					.104	5.296
172.	5.59	.110	.59					.111	5.479
163.	5.76	.118	.63					.119	5.641
155.	5.90	.127	.67					.128	5.772
148.	6.08	.136	.71					.137	5.943
141.	6.22	.146	.75					.147	6.073
134.	6.38	.155	.79					.156	6.224
127.	6.55	.167	.84					.168	6.382
121.	6.72	.176	.89					.177	6.543
115.	6.95	.187	.95					.188	6.762
109.6	7.17	.200	.99					.201	6.969
104.2	7.40	.211	1.04					.212	7.188
99.1	7.60	.225	1.10					.226	7.374
94.3	7.80	.237	1.17					.238	7.562
89.7	8.00	.250	1.24					.251	7.749
85.3	8.20	.263	1.31					.264	7.936
81.2	8.40	.277	1.38					.278	8.122
77.2	8.60	.292	1.44					.293	8.307
73.4	8.80	.308	1.52					.310	8.490
69.9	9.00	.322	1.60					.324	8.676
66.6	9.20	.339	1.68					.341	8.859
63.3	9.40	.356	1.76					.358	9.042
60.1	9.60	.374	1.84					.376	9.224
57.2	9.80	.392	1.92					.394	9.406
54.4	10.00	.410	2.00					.412	9.588

Table 1 — (Continued)

E, ev	σ_T barns	$\sigma_{n,\gamma}$ barns	$\sigma_{n,p}$ mb	$\sigma_{n,\alpha}$ mb	$\sigma_{n,d}$ barns	$\sigma_{n,2n}$ mb	$\sigma_{n,n'}$ barns	$\sigma_{n,x}$ barns	σ_n barns
51.8	10.25	.429	2.10	.0	.000	.0	.000	.431	9.819
49.2	10.50	.450	2.20					.452	10.048
46.8	10.75	.471	2.30					.473	10.277
44.5	11.00	.490	2.40					.492	10.508
42.4	11.20	.510	2.50					.513	10.687
40.3	11.40	.535	2.57					.538	10.862
38.3	11.60	.560	2.68					.563	11.037
36.5	11.80	.582	2.77					.585	11.215
34.7	12.00	.608	2.87					.611	11.389
33.0	12.25	.635	2.97					.638	11.612
31.4	12.50	.660	3.11					.663	11.837
29.9	12.75	.688	3.21					.691	12.059
28.4	13.00	.718	3.35					.721	12.279
27.0	13.20	.750	3.49					.753	12.447
25.7	13.40	.780	3.62					.784	12.616
24.4	13.60	.810	3.75					.814	12.786
23.3	13.75	.840	3.88					.844	12.906
22.1	13.90	.880	4.00					.884	13.016
21.0	14.05	.918	4.15					.922	13.128
20.0	14.20	.950	4.30					.954	13.246
19.0	14.40	.985	4.43					.989	13.411
18.1	14.60	1.025	4.57					1.030	13.570
17.2	14.80	1.055	4.73					1.060	13.740
16.3	15.00	1.100	4.90					1.105	13.895
15.5	15.10	1.145	5.05					1.150	13.950
14.8	15.25	1.180	5.20					1.185	14.065
14.1	15.40	1.220	5.35					1.225	14.175
13.4	15.55	1.260	5.55					1.266	14.284
12.7	15.70	1.310	5.75					1.316	14.384
12.1	15.85	1.355	5.95					1.361	14.489
11.5	16.00	1.395	6.10					1.401	14.599
10.96	16.10	1.435	6.25					1.441	14.659
10.42	16.20	1.480	6.45					1.486	14.714
9.91	16.30	1.525	6.65					1.532	14.768

Table 1 — (Continued)

E, ev	σ_T barns	$\sigma_{n,\gamma}$ barns	$\sigma_{n,p}$ mb	$\sigma_{n,\alpha}$ mb	$\sigma_{n,d}$ barns	$\sigma_{n,2n}$ mb	$\sigma_{n,n'}$ barns	$\sigma_{n,x}$ barns	σ_n barns
9.43	16.40	1.580	6.90	.0	.000	.0	.000	1.587	14.813
8.97	16.55	1.630	7.10					1.637	14.913
8.53	16.65	1.685	7.30					1.692	14.958
8.12	16.80	1.735	7.50					1.743	15.057
7.72	16.95	1.790	7.75					1.798	15.152
7.34	17.05	1.840	7.95					1.848	15.202
6.99	17.15	1.900	8.15					1.908	15.242
6.66	17.25	1.96	8.4					1.968	15.282
6.33	17.35	2.02	8.65					2.029	15.321
6.01	17.45	2.09	8.9					2.099	15.351
5.72	17.55	2.15	9.2					2.159	15.391
5.44	17.65	2.20	9.4					2.209	15.441
5.18	17.75	2.25	9.6					2.260	15.490
4.92	17.85	2.31	9.9					2.320	15.530
4.68	17.95	2.40	10.2					2.410	15.540
4.45	18.05	2.49	10.5					2.501	15.549
4.24	18.15	2.56	10.8					2.571	15.579
4.03	18.25	2.62	11.1					2.631	15.619
3.83	18.40	2.69	11.4					2.701	15.699
3.65	18.50	2.76	11.7					2.772	15.728
3.47	18.60	2.83	12.0					2.842	15.758
3.30	18.75	2.90	12.3					2.912	15.838
3.14	18.90	3.00	12.7					3.013	15.887
2.99	19.00	3.10	13.0					3.113	15.887
2.84	19.10	3.18	13.3					3.193	15.907
2.70	19.20	3.26	13.7					3.274	15.926
2.57	19.30	3.33	14.0					3.344	15.956
2.44	19.40	3.40	14.3					3.414	15.986
2.33	19.50	3.50	14.7					3.515	15.985
2.21	19.60	3.60	15.1					3.615	15.985
2.10	19.70	3.69	15.5					3.706	15.994
2.00	19.80	3.76	15.9					3.776	16.024
1.90	19.90	3.88	16.3					3.896	16.004
1.81	20.00	3.98	16.8					3.997	16.003

Table 1 — (Continued)

E, ev	σ_T barns	$\sigma_{n,\gamma}$ barns	$\sigma_{n,p}$ mb	$\sigma_{n,\alpha}$ mb	$\sigma_{n,d}$ barns	$\sigma_{n,2n}$ mb	$\sigma_{n,n'}$ barns	$\sigma_{n,x}$ barns	σ_n barns
1.72	20.08	4.09	17.3	.0	.000	.0	.000	4.107	15.975
1.63	20.16	4.20	17.8					4.218	15.942
1.55	20.25	4.30	18.2					4.318	15.932
1.48	20.33	4.40	18.6					4.419	15.911
1.41	20.42	4.50	19.0					4.519	15.901
1.34	20.50	4.61	19.5					4.630	15.870
1.27	20.58	4.72	20.0					4.740	15.840
1.21	20.67	4.85	20.6					4.871	15.799
1.15	20.75	5.00	21.1					5.021	15.729
1.096	20.83	5.12	21.6					5.142	15.688
1.042	20.92	5.24	22.1					5.262	15.658
.991	21.00	5.36	22.7					5.383	15.617
.943	21.20	5.48	23.3					5.503	15.697
.897	21.40	5.61	23.9					5.634	15.766
.853	21.60	5.75	24.5					5.775	15.825
.812	21.80	5.97	25.1					5.995	15.805
.772	22.00	6.10	25.8					6.126	15.874
.734	22.20	6.25	26.5					6.277	15.923
.699	22.40	6.38	27.2					6.407	15.993
.666	22.60	6.50	27.9					6.528	16.072
.633	22.80	6.65	28.8					6.679	16.121
.601	23.00	6.80	29.5					6.830	16.170
.572	23.20	7.00	30.1					7.030	16.170
.544	23.40	7.20	30.9					7.231	16.169
.518	23.60	7.40	31.7					7.432	16.168
.492	23.80	7.60	32.5					7.633	16.167
.468	24.00	7.80	33.4					7.833	16.167
.445	24.20	7.97	34.3					8.004	16.196
.424	24.40	8.15	35.2					8.185	16.215
.403	24.60	8.38	36.1					8.416	16.184
.383	24.80	8.56	37.0					8.597	16.203
.365	25.00	8.78	38.0					8.818	16.182
.347	25.25	9.00	39.0					9.039	16.211
.330	25.50	9.25	40.0					9.290	16.210
.314	25.75	9.45	41.0					9.491	16.259

Table 1 — (Continued)

E, ev	σ_T barns	$\sigma_{n,\gamma}$ barns	$\sigma_{n,p}$ mb	$\sigma_{n,\alpha}$ mb	$\sigma_{n,d}$ barns	$\sigma_{n,2n}$ mb	$\sigma_{n,n'}$ barns	$\sigma_{n,x}$ barns	σ_n barns
.299	26.00	9.65	42.0	.0	.000	.0	.000	9.692	16.308
.284	26.30	10.0	43.1					10.043	16.257
.270	26.60	10.2	44.2					10.244	16.356
.257	26.90	10.4	45.4					10.445	16.455
.244	27.20	10.7	46.5					10.746	16.454
.233	27.50	11.0	47.7					11.048	16.452
.221	27.80	11.3	49.0					11.349	16.451
.210	28.10	11.6	50.0					11.650	16.450
.200	28.40	11.9	51.5					11.952	16.448
.190	28.70	12.2	52.5					12.253	16.447
.181	29.10	12.5	54.0					12.554	16.546
.172	29.40	12.8	56.0					12.856	16.544
.163	29.80	13.1	57.5					13.158	16.642
.155	30.00	13.5	59.0					13.559	16.441
.148	30.30	13.8	60.0					13.860	16.440
.141	30.60	14.2	61.0					14.261	16.339
.134	31.00	14.6	62.5					14.663	16.337
.127	31.40	15.0	64.0					15.064	16.336
.121	31.80	15.4	66.0					15.466	16.334
.115	32.20	15.8	68.0					15.868	16.332
.1096	32.60	16.1	69.5					16.170	16.430
.1042	33.00	16.5	71.0					16.571	16.429
.0991	33.30	16.9	72.5					16.973	16.327
.0943	33.70	17.3	74.5					17.375	16.325
.0897	34.20	17.8	76.5					17.877	16.323
.0853	34.60	18.2	78.5					18.279	16.321
.0812	35.00	18.7	80.5					18.781	16.219
.0772	35.40	19.2	82.5					19.283	16.117
.0734	35.80	19.7	84.5					19.785	16.015
.0699	36.20	20.2	86.5					20.287	15.913
.0666	36.60	20.7	89.0					20.789	15.811
.0633	37.10	21.2	91.0					21.291	15.809
.0601	37.60	21.7	93.5					21.794	15.806
.0572	38.20	22.2	96.0					22.296	15.904
.0544	38.80	22.8	98.0					22.898	15.902

Table 1 — (Continued)

E, ev	σ_T barns	$\sigma_{n,\gamma}$ barns	$\sigma_{n,p}$ mb	$\sigma_{n,\alpha}$ mb	$\sigma_{n,d}$ barns	$\sigma_{n,2n}$ mb	$\sigma_{n,n'}$ barns	$\sigma_{n,x}$ barns	σ_n barns
.0518	39.30	23.3	100.	.0	.000	.0	.000	23.400	15.900
.0492	40.00	24.0	103.					24.103	15.897
.0468	40.50	24.7	105.					24.805	15.695
.0445	41.10	25.3	108.					25.408	15.692
.0424	41.60	25.9	111.					26.011	15.589
.0403	42.20	26.6	114.					26.714	15.486
.0383	42.90	27.2	117.					27.317	15.583
.0365	43.40	27.9	120.					28.020	15.380
.0347	43.90	28.7	123.					28.823	15.077
.0333	44.40	29.3	126.					29.426	14.974
.0314	45.00	30.1	129.					30.229	14.771
.0299	45.60	31.0	133.					31.133	14.467
.0284	46.20	31.9	136.					32.036	14.164
.0270	46.80	32.8	139.					32.939	13.861
.0257	47.40	33.6	143.					33.743	13.657
.0244	48.00	34.4	146.					34.546	13.454
.0233	48.70	35.2	149.					35.349	13.351
.0221	49.50	36.0	153.					36.153	13.347
.0210	50.20	36.9	158.					37.058	13.142
.0200	51.00	37.9	162.					38.062	12.938
.0190	51.80	38.8	166.					38.966	12.834

In the range from 1100 ev to 0.2 Mev the total cross section was computed from the resonance parameters given below, as was the value at the peak of the 405 ev resonance, shown in the tables at 403 ev.

Isotope	E_0	Γ_n^0	Γ_γ	Γ_p	g	ℓ	Reference
35	- 210	1.38	0.5	0.0024	5/8	0	3
35	405	0.001888	0.5	0.070	5/8	1	3
35	1100	0.000169	0.5	0.050	5/8	1	3
35	4300	0.003965	0.5	0.035	5/8	1	3
37	8700	0.536	0.5	0	1/2	0	2
35	15×10^3	0.245	0.5	0.10	1/2	0	3
35	17×10^3	0.268	0.5	0.10	1/2	0	3
–	25.5×10^3	1.566	0.5	0	1/2	0	2
35	27×10^3	1.065	0.5	0	1/2	0	2
–	47×10^3	1.617	0.5	0	1/2	0	2
–	55×10^3	0.235	0.5	0	1/2	0	2
–	59×10^3	0.371	0.5	0	1/2	0	2
–	63×10^3	0.339	0.5	0	1/2	0	2
–	68.5×10^3	0.478	0.5	0	1/2	0	2
35	102×10^3	0.751	0.5	0	1/2	0	2
35	113×10^3	1.487	0.5	0	1/2	0	2
37	125×10^3	0.424	0.5	0	1/2	0	2
37	128×10^3	0.839	0.5	0	1/2	0	2
35	135×10^3	1.633	0.5	0	1/2	0	2
37	139×10^3	2.146	0.5	0	1/2	0	2
35	143×10^3	1.058	0.5	0	1/2	0	2
37	145×10^3	3.808	0.5	0	1/2	0	2
37	159×10^3	1.755	0.5	0	1/2	0	2
37	180×10^3	2.593	0.5	0	1/2	0	2
35	190×10^3	2.753	0.5	0	1/2	0	2
37	193×10^3	1.480	0.5	0	1/2	0	2
35	202×10^3	6.230	0.5	0	1/2	0	2

σ_{pot} = 1.2 b. Energies and widths are given in ev. Where isotopic assignments were made, the factor g was weighted by the isotopic abundance a in the calculations. Where there is no assignment, g was used without weighting. a (35) = 0.754, a (37) = 0.246.

1.1.2 The (n,γ) Cross Section

The radiative capture cross section was measured by Meadows and Whalen[4] at 0.0253 ev. Their value is 34.2 barns. Popov and Shapiro,[3,5] whose parameters we have used for the lowest few resonances, use the value from BNL 325, 33.6 b. For consistency with the resonance calcuations, we also have used 33.6 b at 0.025 ev. A 1/v line was carried through this point to 2 ev and then faired into the cross-section curve calculated from the resonance parameters, finally coinciding with that curve at about 40 ev. The calculated curve was followed up to 0.21 Mev above which a 1/E line was followed passing through 0.1 mb at about 0.3 Mev. The cross section was considered to go to zero at about 2 Mev because of competition with other reactions.

1.1.3 The (n,p) Cross Section

For neutron energies below about 18 kev, the (n,p) cross section was calculated from resonance parameters. Above this energy, we found only one measurement of $\sigma_{n,p}$ in Cl^{35}, that of Scalan and Fink[6] at 14.8 Mev. To give an indication of the rising part of the cross section at high energies we have, therefore, adapted the curve of $\sigma_{n,p}$ in phosphorus given in BNL 325.[1] Phosphorus is an odd-odd nucleus, as is Cl^{35}. In addition, the Q value for the reaction in phosphorus is not vastly different from the corresponding Q in chlorine so that the competition due to neutron emission does not lead to very different level densities. Ashby and Catron[7] give -0.7025 Mev as the Q for the (n,p) reaction in phosphorus and +0.6139 Mev in Cl^{35}. Thus, the steep rise in the $\sigma_{n,p}$ curve in Cl^{35} should appear at an energy about 1.3 Mev below that at which it appears in P. Accordingly, we have used a smoothed version of the $\sigma_{n,p}$ curve for P shifted in energy so that it rises most steeply at about 0.5 Mev and becomes flat at about 4.5 Mev, remaining so until about 8 Mev. The curve was then brought down through Scalan and Fink's point at 14.8 Mev. For inclusion in this compilation the values had, of course, to be weighted by 0.754, the abundance of Cl^{35} in natural Cl. In the range between 18 kev and about 0.5 Mev, a 1/E curve was used which passed through 0.13 mb at 20 kev.

BNL 325[1] shows a curve of $\sigma_{n,p}$ in Cl^{37} rising sharply at about 12 Mev, and Scalan and Fink[6] have measured this cross section at 14.8 Mev. These values are in good agreement and were included in the tabulations weighted by the abundance of Cl^{37}.

1.1.4 The (n,α) Cross Section

In the range from 3 to 4 Mev, data for the (n,α) cross section in Cl^{35} came from BNL 325.[1] The gap between this steeply rising part of the curve and the point at 14.8 Mev measured by Scalan and Fink[6] was bridged by a curve which rises to a peak at about 8 Mev and descends again at higher energies.

The only measurement found of $\sigma_{n,\alpha}$ in Cl^{37} is that of Scalan and Fink[6] at 14.8 Mev. From examination of the Q values of Ashby and Catron[7] for (n,p) and (n,α) reactions in nearby odd-odd nuclides, we concluded that the (n,α) reaction could be expected to appear about 1 Mev below the (n,p) reaction. Accordingly, we have drawn the curve for $\sigma_{n,\alpha}$ starting at about 11 Mev and passing through Scalan and Fink's point at 14.8 Mev.

1.1.5 The (n,2n) Cross Section

Scalan and Fink[6] have measured cross sections for the (n,2n) reaction leading to the ground state of Cl^{34} and to the 32.4 minute isomer. The sum of these has been taken to be the (n,2n) cross section in Cl^{35}. Ashby and Catron[7] give the Q value for the (n,2n) reaction in Cl^{35} as -12.5 Mev. We have taken 12.5 Mev as the threshold for the reaction and have drawn a curve through Scalan and Fink's point. The Q value for (n,2n) in Cl^{37} is -10.3 Mev,[7] and no measurement of $\sigma_{n,2n}$ in this isotope was found in the literature. Because of this and because Cl^{37} is also three times less abundant than Cl^{35}, we have taken $\sigma_{n,2n}$ in Cl^{35} to be $\sigma_{n,2n}$ in natural chlorine.

1.1.6 The (n,n′) and (n,x) Cross Sections

No measurements of inelastic scattering of neutrons by chlorine were found. In the range from 4 to 11 Mev, values of the elastic scattering cross section were

taken from the work of Longley[8] and subtracted from values of the total cross section from BNL 325.[1] The resulting nonelastic cross section was extended to lower energies by assuming it to be equal to the (n,p) cross section at 1 Mev. It was assumed to be constant at 1 b above 11 Mev.

The Landolt-Börnstein tables[9] show the first excited level in Cl^{35} at 1.22 Mev and that in Cl^{37} at 0.838 Mev. The spin and parity assignments, however, are insufficient to permit Hauser-Feshbach calculations of cross sections for the excitation of individual levels. We therefore have taken the total inelastic scattering cross section to be the difference between the nonelastic cross section described above and the sum of the cross sections for all of the other nonelastic reactions. In the region around 12 Mev, however, this technique led to a rise in $\sigma_{n,n'}$ which we considered to be very unlikely behavior. Therefore, we led the $\sigma_{n,n'}$ curve smoothly downward and ascribed that part of $\sigma_{n,x}$ to the appearance of a charged particle reaction for which no measurements were available. It should be mentioned here that the use of Longley's[8] values of σ_n and the BNL 325[1] values of σ_T gives a rising curve of $\sigma_{n,x}$ in this range, making the situation worse rather than better.

Table 2 displays the cross section for inelastic scattering of neutrons from energy E to energy E′. It was calculated using a complete statistical assumption[10] and the following parameters:

E_1 = 1.0 Mev, energy of first level

E_0 = 4.0 Mev, energy of transition to exponential density of levels

B = 1.0/Mev, level density for $E_1 \geqslant E \geqslant E_0$

a = 3.6/Mev, level density parameter for exponential distribution

density = $\exp(\sqrt{2aE})$ for E > E.

The spectrum of gamma rays following inelastic neutron scattering was computed using Troubetzkoy's statistical theory[11] as embodied in the GRAINS computer program. The same level density parameters were used as for the neutron spectrum. This spectrum is shown in Table 3.

Table 2 — Chlorine – Cross Sections for the Production of Inelastic Neutrons

E, Mev	$\sigma_{n,n'}$ barns	$\sigma_{n,n'}(E,E')$, barns/Mev, for E′ given in Mev 0.5	1.0	1.5	2.0	3.0	4.0	6.0	8.0	10.0
18.0	.704	.0683	.1063	.1295	.1360	.1257	.1021	.0533	.0228	.00803
17.1	.707	.0728	.1110	.1341	.1404	.1301	.1025	.0516	.0209	.00672
16.3	.710	.0774	.1186	.1399	.1444	.1310	.1019	.0497	.0192	.00604
15.5	.716	.0809	.1242	.1453	.1504	.1337	.1020	.0474	.0174	.00487
14.75	.720	.0864	.1310	.1511	.1553	.1359	.1033	.0451	.0153	.00396
14.0	.724	.0883	.1372	.1583	.1596	.1376	.1022	.0431	.0135	.00398
13.3	.735	.0948	.1444	.1659	.1658	.1402	.1014	.0406	.0118	.00478
12.7	.742	.1005	.1517	.1704	.1707	.1419	.1011	.0384	.0102	.00742
12.1	.755	.1031	.1582	.1784	.1765	.1438	.1004	.0362	.0089	.01004
11.5	.773	.1098	.1687	.1863	.1837	.1465	.1001	.0335	.0118	.01507
10.9	.788	.1170	.1761	.1942	.1886	.1475	.0982	.0307	.0182	.0
10.4	.804	.1246	.1837	.2006	.1942	.1479	.0961	.0280	.0257	
9.89	.829	.1409	.1990	.2096	.1983	.1492	.0942	.0279	.0372	
9.41	.856	.1370	.2026	.2156	.2050	.1481	.0912	.0394	.0529	
8.95	.894	.1395	.2110	.2235	.2092	.1489	.0872	.0561	.0745	
8.51	.923	.1495	.2178	.2294	.2123	.1463	.0840	.0785	.0	
8.10	.944	.1510	.2209	.2275	.2084	.1397	.0774	.1051		
7.70	.974	.1544	.2179	.2242	.2023	.1321	.0934	.1400		
7.33	.995	.1522	.2169	.2219	.1985	.1261	.1224	.1846		
6.97	1.008	.1502	.2082	.2097	.1852	.1220	.1542	.2319		
6.63	1.002	.1463	.1987	.1974	.1713	.1445	.1924	.0		
6.30	.998	.1337	.1823	.1788	.1524	.1634	.2211			
6.00	.975	.1214	.1626	.1576	.1380	.1989	.2652			
5.70	.948	.1119	.1474	.1416	.1564	.2335	.3113			
5.43	.924	.1044	.1337	.1349	.1800	.2700	.3600			
5.16	.893	.0996	.1143	.1482	.1982	.2869	.3964			
4.91	.850	.0886	.1016	.1655	.2203	.3315	.0			
4.67	.836	.0711	.1212	.1822	.2430	.3647				
4.44	.820	.0686	.1378	.2075	.2604	.3905				
4.23	.803	.0779	.1555	.2345	.3120	.4590				
4.02	.784	.0847	.1693	.2532	.3371	.5057				
3.82	.767	.0964	.1929	.2893	.3858	.0				
3.64	.749	.1075	.2149	.3224	.4299					
3.46	.728	.1203	.2406	.3609	.4812					
3.29	.699	.1333	.2666	.3999	.5332					
3.13	.674	.1486	.2971	.4457	.5942					
2.97	.649	.1672	.3345	.5017	.0					
2.83	.625	.1866	.3733	.5599						
2.69	.597	.2090	.4181	.6271						
2.56	.578	.2375	.4750	.7125						
2.44	.561	.2705	.5411	.0						
2.32	.540	.3099	.6198							
2.21	.518	.3538	.7076							
2.10	.492	.4066	.8132							
2.00	.464	.4640	.0							
1.90	.430	.5309								
1.81	.393	.5990								
1.72	.354	.6829								
1.63	.335	.8440								
1.55	.314	1.0380								
1.48	.294	.0								

Table 3 — Chlorine – Cross Sections for Gamma Ray Production Following Neutron Inelastic Scattering

		$\sigma_{n,n'\gamma}(E,E_\gamma)$, barns, for E_γ between Group Boundaries, given in Mev									
E, Mev	$\sigma_{n,n'}$ barns	0-.5	.5-1.	1.-1.5	1.5-2.	2.-3.	3.-4.	4.-6.	6.-8.	8.-10.	10.-18
18.0	.704	.001	.014	.134	.115	.210	.206	.425	.346	.208	.172
17.1	.707	.001	.014	.134	.115	.206	.198	.404	.326	.195	.163
16.3	.710	.001	.014	.134	.114	.202	.191	.384	.307	.185	.156
15.5	.716	.001	.014	.134	.114	.198	.184	.364	.289	.177	.149
14.75	.720	.001	.013	.135	.113	.194	.176	.343	.272	.173	.139
14.0	.724	.001	.013	.135	.112	.189	.167	.321	.258	.172	.127
13.3	.735	.001	.013	.136	.112	.186	.160	.304	.250	.176	.109
12.7	.742	.001	.013	.137	.112	.182	.153	.289	.246	.179	.090
12.1	.755	.001	.013	.140	.113	.181	.147	.277	.248	.180	.069
11.5	.773	.001	.014	.143	.114	.179	.142	.270	.256	.177	.046
10.9	.788	.001	.014	.146	.116	.178	.138	.267	.265	.165	.023
10.4	.804	.001	.014	.150	.118	.178	.135	.271	.272	.149	.006
9.89	.829	.001	.014	.156	.122	.180	.136	.282	.276	.118	.000
9.41	.856	.001	.015	.162	.126	.185	.139	.296	.274	.082	
8.94	.894	.001	.015	.172	.133	.194	.146	.315	.266	.049	
8.51	.923	.001	.016	.181	.140	.204	.154	.328	.247	.018	
8.10	.944	.001	.017	.190	.147	.215	.163	.334	.212	.001	
7.70	.974	.001	.018	.202	.156	.230	.174	.335	.162	.000	
7.33	.995	.001	.019	.214	.166	.245	.184	.325	.115		
6.97	1.008	.001	.020	.225	.176	.261	.190	.306	.071		
6.63	1.002	.001	.020	.234	.183	.272	.191	.277	.034		
6.30	.998	.001	.021	.243	.192	.283	.190	.240	.001		
6.00	.975	.001	.021	.248	.196	.287	.183	.193	.000		
5.70	.948	.001	.021	.252	.200	.289	.172	.143			
5.43	.924	.001	.022	.256	.203	.289	.162	.104			
5.16	.893	.001	.022	.258	.204	.285	.148	.070			
4.91	.850	.001	.021	.256	.201	.274	.133	.044			
4.67	.836	.001	.022	.262	.205	.272	.121	.025			
4.44	.820	.001	.022	.267	.207	.267	.108	.011			
4.23	.803	.001	.022	.272	.209	.260	.093	.003			
4.02	.784	.001	.023	.277	.210	.251	.074	.000			
3.82	.767	.001	.023	.282	.212	.242	.054				
3.64	.749	.001	.023	.288	.212	.231	.037				
3.46	.728	.001	.023	.293	.212	.217	.022				
3.29	.699	.001	.023	.295	.209	.197	.010				
3.13	.674	.001	.023	.298	.206	.176	.002				
2.97	.649	.001	.023	.303	.204	.148	.000				
2.83	.625	.001	.023	.307	.200	.122					
2.69	.597	.001	.023	.311	.194	.095					
2.56	.578	.001	.023	.318	.190	.071					
2.44	.561	.001	.023	.327	.184	.050					
2.32	.540	.001	.024	.335	.174	.030					
2.21	.518	.001	.024	.342	.161	.015					
2.10	.492	.001	.024	.348	.141	.007					
2.00	.464	.001	.024	.349	.115	.000					
1.90	.430	.001	.025	.346	.084						
1.81	.393	.000	.025	.336	.057						
1.72	.354	.000	.025	.321	.033						
1.63	.335	.000	.027	.320	.014						
1.55	.314	.000	.029	.311	.009						
1.48	.294	.000	.031	.293	.000						
1.41	.270	.000	.033	.269							
1.34	.243	.000	.036	.242							
1.27	.210	.000	.039	.208							
1.21	.176	.000	.042	.174							
1.15	.139	.000	.046	.139							
1.096	.097	.000	.050	.095							
1.042	.047	.000	.047	.039							

1.1.7 The (n,d) Cross Section

Ashby and Catron[7] give the Q value for the (n,d) reaction in Cl^{35} as -4.14 Mev and, in Cl^{37}, as -6.17 Mev. No measurements of cross sections for this reaction were found in the literature. We have ascribed the extra part of $\sigma_{n,x}$ to this reaction. That the cross section rises steeply at about 11 Mev, rather than about 4 Mev as given by the Q value for (n,d) in Cl^{35}, is not implausible. Coulomb barrier effects and competition of the (n,p) and (n,α) reactions both may be expected to inhibit the (n,d) reaction for some distance above its threshold.

1.1.8 The Elastic Scattering Cross Section, σ_n

In the range of incident neutron energies from 4 to 11 Mev values of σ_n were taken from the work of Longley.[8] Elsewhere the relation $\sigma_n = \sigma_T - \sigma_{n,x}$ was used.

1.2 ANGULAR DISTRIBUTION OF ELASTICALLY SCATTERED NEUTRONS

Guseinov and Nikolaev[12] show the angular distribution of fast neutrons elastically scattered from chlorine to be similar to that from potassium. We, therefore, have used the Legendre coefficients for potassium from UNC-5002.[13] (See Table 4.)

1.3 GAMMA RAYS FROM NEUTRON CAPTURE

Groshev[14] lists 31 gamma rays emitted in the capture of thermal neutrons by chlorine. These are listed below. We have assumed that the spectrum of gammas is independent of the energy of the captured neutron.

E_γ, Mev	Intensity, %	E_γ, Mev	Intensity, %	E_γ, Mev	Intensity, %
8.58	2.8	4.79	1.9	2.88	9.5
7.79	7.8	4.64	2.3	2.83	2.
7.42	14.	4.50	2.2	2.71	2.
6.99	1.9	4.15	2.3	2.51	1.
6.64	14.4	4.05	2.1	1.95	29.
6.11	21.4	3.90	1.8	1.72	1.
5.72	5.6	3.63	2.9	1.67	1.
5.50	2.	3.40	3.6	1.60	2.4
5.28	1.6	3.08	4.5	1.165	36.
4.98	6.	3.02	3.5	0.79	23.
				0.51	<26.

Table 4 — Chlorine – Legendre Expansion Coefficients for the Angular Distribution of Elastically Scattered Neutrons

E, Mev	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8
18.00	.721	.571	.437	.384	.314	.261	.222	.135
17.10	.718	.568	.442	.385	.312	.259	.216	.128
16.30	.716	.566	.448	.386	.308	.256	.209	.120
15.50	.715	.565	.456	.385	.303	.253	.202	.110
14.75	.715	.564	.463	.384	.296	.248	.193	.098
14.00	.715	.564	.467	.380	.288	.233	.182	.082
13.30	.715	.563	.467	.370	.272	.214	.167	.066
12.70	.716	.564	.461	.356	.248	.195	.151	.050
12.10	.720	.565	.451	.342	.226	.176	.134	.040
11.50	.732	.567	.443	.328	.204	.160	.112	.033
10.90	.744	.571	.437	.316	.184	.144	.092	.026
10.40	.754	.577	.431	.304	.172	.130	.077	.022
9.89	.762	.581	.427	.288	.161	.118	.064	.018
9.41	.770	.586	.423	.270	.152	.107	.054	.015
8.95	.776	.589	.420	.258	.141	.096	.046	.012
8.51	.779	.592	.416	.239	.131	.086	.039	.010
8.10	.780	.593	.412	.221	.120	.076	.032	.009
7.70	.781	.593	.407	.193	.110	.068	.025	.008
7.33	.780	.591	.400	.169	.100	.060	.019	.006
6.97	.778	.587	.392	.140	.090	.053	.014	.005
6.63	.725	.554	.378	.119	.081	.046	.010	.003
6.30	.668	.514	.340	.103	.071	.039	.007	.002
6.00	.640	.480	.297	.092	.062	.033	.004	.002
5.70	.599	.450	.272	.085	.053	.027	.002	.001
5.43	.560	.430	.252	.080	.045	.022	.000	.001
5.16	.520	.413	.233	.076	.039	.017	-.001	.000
4.91	.491	.399	.218	.072	.033	.013	-.001	
4.67	.455	.386	.202	.068	.028	.010	-.002	
4.44	.423	.374	.185	.065	.023	.007	-.002	
4.23	.397	.364	.170	.061	.019	.005	-.002	
4.02	.370	.352	.156	.058	.016	.004	-.001	
3.82	.342	.341	.142	.055	.013	.003	-.001	
3.64	.323	.332	.130	.052	.010	.002	-.001	
3.46	.310	.321	.116	.049	.007	.002	-.001	
3.29	.295	.312	.104	.046	.004	.001	.000	

Table [illegible] — (Continued)

E, Mev	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8
3.13	.283	.303	.094	.044	.002	.001	.000	.000
2.97	.267	.294	.084	.041	.001	.001		
2.83	.260	.286	.074	.039	-.001	.001		
2.69	.248	.277	.066	.036	-.002	.000		
2.56	.240	.269	.058	.034	-.002			
2.44	.230	.261	.052	.032	-.002			
2.32	.222	.253	.045	.030	-.003			
2.21	.216	.246	.038	.028	-.003			
2.10	.207	.238	.029	.026	-.003			
2.00	.201	.230	.022	.024	-.003			
1.90	.195	.225	.014	.023	-.002			
1.81	.190	.219	.005	.022	-.002			
1.72	.182	.210	-.001	.022	-.002			
1.63	.180	.207	-.004	.022	-.002			
1.55	.178	.201	-.007	.022	-.002			
1.48	.177	.199	-.010	.022	-.001			
1.41	.177	.197	-.010	.021	-.001			
1.34	.180	.194	-.009	.021	-.001			
1.27	.210	.191	-.008	.020	-.001			
1.21	.228	.189	-.008	.020	-.001			
1.15	.240	.188	-.007	.019	-.001			
1.096	.238	.185	-.006	.018	-.001			
1.042	.232	.183	-.004	.018	.000			
E, kev								
991.00	.210	.180	.000	.016				
943.00	.190	.175	.001	.015				
897.00	.180	.167	.002	.013				
853.00	.163	.159	.001	.011				
812.00	.150	.140	.000	.010				
772.00	.130	.113	-.001	.009				
734.00	.115	.095	-.002	.008				
699.00	.085	.092	-.005	.007				
666.0	.050	.100	-.006	.006				
632.0	.040	.108	-.006	.006				
601.00	.058	.107	-.005	.005				
572.00	.085	.102	-.005	.004				

Table 4 — (Continued)

E, kev	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8
544.00	.115	.100	−.005	.004	.000	.000	.000	.000
518.00	.128	.091	−.005	.003				
492.00	.135	.085	−.005	.003				
468.00	.137	.080	−.005	.002				
445.00	.134	.073	−.004	.002				
424.00	.130	.067	−.004	.002				
403.00	.124	.062	−.004	.001				
383.00	.122	.060	−.003	.001				
365.00	.120	.055	−.003	.001				
347.00	.117	.050	−.002	.001				
330.00	.115	.046	−.002	.000				
314.00	.113	.042	−.002					
299.00	.112	.040	−.001					
284.00	.110	.038	−.001					
270.00	.109	.035	−.001					
257.00	.107	.032	.000					
244.00	.105	.029						
233.00	.098	.026						
221.00	.091	.024						
210.00	.085	.021						
200.00	.080	.020						
190.00	.071	.019						
181.00	.064	.017						
172.00	.057	.016						
163.00	.048	.014						
155.00	.042	.012						
148.00	.038	.011						
141.00	.032	.010						
134.00	.028	.009						
127.00	.022	.008						
121.00	.018	.007						
115.00	.016	.006						
109.60	.013	.006						
104.20	.011	.005						
99.10	.009	.004						
94.30	.008	.004						

Table 4 — (Continued)

E, kev	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8
89.70	.007	.003	.000	.000	.000	.000	.000	.000
85.30	.006	.003						
81.20	.005	.003						
77.20	.005	.002						
73.40	.004	.002						
69.90	.004	.002						
66.60	.003	.001						
63.20	.003	.001						
60.10	.003	.001						
57.20	.002	.001						
54.40	.002	.001						
51.80	.002	.001						
49.20	.002	.001						
46.80	.002	.000						
44.50	.001							
42.40	.001							
40.30	.001							
38.30	.001							
36.50	.001							
34.70	.001							
33.00	.001							
31.40	.001							
29.90	.001							
28.40	.001							
27.00	.001							
25.70	.001							
24.40	.001							
23.30	.001							
22.10	.001							
21.00	.001							
20.00	.001							
19.00	.001							
18.10	.001							
17.20	.001							
16.30	.000							

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